Costs and benefits of addressing environmental impacts in the wet coffee processing in Rwanda

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List of acronyms

BOP	:	Balance of Payments
CDM	:	Clean Development Mechanisms
CWS	:	Coffee Washing Stations
EDPRS	:	Economic Development and Poverty Reduction Strategy
GoR	:	Government of Rwanda
ICO	:	International Coffee Organisation
IFC	:	International Finance Corporation
LCA	:	Life Cycle Assessments
MINAGRI	:	Ministry of Agriculture and Animal Resources
MTC	:	Mountain Top Coffee
NBR	:	National Bank of Rwanda
NPV	:	Net Present Value
OECD	:	Organisation for Economic Co-operation and Development
PEI	:	Poverty Environment Initiative
REMA	:	Rwanda Environment Management Authority
UN	:	United Nations
UNDP	:	United Nations Development Programme
UNEP	:	United Nations Environment Programme
USAID	:	United States Agency for International Development
USD	:	United States Dollars

EXECUTIVE SUMMARY

This paper was commissioned under the auspices of Poverty-Environment Initiative in Rwanda. The main objective was to identify both the positive and negative impacts from wet coffee processing and the benefits and costs associated with them. The goal of the paper was to open up policy dialogue aimed at improving the competitiveness of coffee industry, particularity from the environmental point of view.

The study found that in as much as the wet coffee processors have to address environmental issues, they are not the only ones. Accordingly, the government has to support other players, especially farmers, in the coffee value chain.

Globally, the growing demand for specialty or sustainability coffee with the associated premium prices should serve as incentive for coffee washing stations to reform. However, it is imperative that the premium prices trickle down to farmers also.

Presently, Rwanda's coffee production is fluctuating due to multiple factors: lack of strong incentives, old coffee trees, low yielding varieties to mention but a few. On a positive note, the government has developed a Coffee Strategy aimed at addressing these issues.

At processing level, it was found that many wet coffee stations are not making much profit as they should due to poor supplies of cherries, weak management and poor staffing. They need to address these to be competitive. They could also start to benefit from waste they generate in terms of compost, mushroom growing soil, animal feed supplement and energy source. They must also start to make savings by improving efficiency in energy, water and labour use.

It is thus imperative for policy makers to:

(i) create enabling environment for all actors in the coffee value chain to address environmental issues

(ii) provide incentives to coffee washing stations that want to introduce more environmentally friendly technologies and practices

(iii) lobby at global level for premium prices for sustainable coffee

A: Introduction

1. In 2011, Rwanda was ranked among the ten economies that made the largest strides in making their regulatory environment more favourable for business (World Bank and IFC 2011). This achievement was a reflection of Rwanda's consistent effort since 2005, having implemented 22 regulation reforms in that period. In the same vein, it is investing in improving the competitiveness of its coffee industry. Accordingly, it has formulated a National Coffee Strategy 2009-2012, in which it has stated that "improved profitability and competitiveness of the private sector will result from implementation of the coffee strategy" (pg 47). Among its 5 priorities is a programme to "establish a voluntary turnaround programme to support improved management of coffee washing stations (CWS) that have the potential to become profitable". Under the above strategy, Rwanda targets production of 33,000 tons of coffee by 2012, with 19,000 tons (58%) of this fully washed. In turn, this is expected to generate exports of US $ 115 million by 2012.

2. This report was made under the auspices of Poverty-Environment Initiative (PEI) Rwanda. The initiative is strengthening the capacity of the Government of Rwanda (GoR) in the area of environmental mainstreaming and environmental fiscal reform processes. The private sector too has obligation under national laws and standards to ensure environmental compliance. This paper has thus been written to serve as a basis to create awareness on environment among the coffee sector and to equally mobilize it to start addressing environmental impacts systematically.

3. Presently, Rwanda is disadvantaged because with only 0.4% market share on international market, it has to invest very strategically to overcome **low visibility** on that market. Fully washing the coffee through CWS has been seen as the key to potentially selling it as a specialty produce because it would enable producers to sell their coffee as high grade Arabica, commanding price premiums in the process. The expectation is that the benefits of profitable CWS should trickle down to the coffee producers who are the front runners in the coffee value chain. However, the CWS are but a few of the very many actors in the coffee value chain. Accordingly, beyond targeting CWS, the government has to equally target other actors in the chain so that they all play their comparative roles to give coffee commodity a competitive edge to Rwanda. Top on the list are the households engaged in coffee growing.

4. The priority of this study can be understood in the broader context of Rwanda's EDPRS whose one of its goals is to promote export strategies. With regard to coffee in particular, the GoR is to increase value addition by encouraging and supporting investment in washing stations and processing, and increase sales by improving marketing. On the other hand, the coffee strategy targeted the specialty coffee segment as it enjoys higher and more stable prices than the commercial coffee segment which is subject to global commodity price swings. This strategy is informed by the fact that the specialty coffee segment was projected to grow at 7.2% per year between 2000 and 2010 whereas commercial grade Arabica was expected to fall at 2% year over the same period. Rwanda has all the natural attributes to compete in this segment. Fully washing the coffee through wet processing was seen as the key to potentially selling it as a specialty product (See table 1).

5. Once fully galvanized, the above strategies would contribute to the attainment of per capita income of US$ 900 by 2020 set under Vision 2020 and EDPRS.

6. In 2006, prices gained by CWS for their coffee translated to a premium of 45 cents per lb over the C-Price, placing Rwanda firmly in the fine coffee and specialty price range. Almost 16% of export receipts were from specialty coffee (US$8.5 million from US$ 0 in 2002) even though it was less than 7% of total production. The prices gained by these stations for their coffee averaged $3.60/kg in 2007, translating to a premium of almost $1 per kg over the C-price. So, a premium price serves as an incentive to CWS to reform the sector.

Table 1: Growth in the specialty coffee sector in Rwanda

	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
No. of washing stations	1	10	25	45	76	112	112	112
Tons of green specialty coffee exported	30	300	800	1200	3000	2300	2455	3045
No. of specialty coffee buyers	2	8	16	25	30	30	n/a	n/a
Total value of specialty coffee exported ($1000s)	90	720	1,850	3,168	8,000	7,800	8,060	11,600

Source: http://www.usaid.gov/rw/our_work/programs/docs/factsheets/coffee.pdf

7. In as much as Rwanda is pursuing export growth, it is also pursuing sustainable environmental management. It is one of the EDPRS goals to "Manage the environment and ensure optimal utilisation of natural resources". Among other targets are those to increase forest and agro-forest coverage from 20% to 23% of total surface land area and to reduce soil erosion and soil fertility decline by 24% over the EDPRS period. Although it is beyond the scope of this study, its worth for Rwanda to recognise that there are many economic and environmental benefits it could earn by growing coffee under shade (Box 1).

Box 1: Economic and ecological benefits of "shade-grown coffee"

Rwanda like many countries adopted "sun cultivation" method which allows the berries to ripen a lot faster, and increase production yields. That has come with its costs: deforestation destruction of wildlife habitat, decreased soil quality and increased erosion, pollution from chemicals and pesticides, and decreased life of coffee plants

Rwanda should in future explore to adopt "shade grown coffee", that is, the plants are grown under the shades of trees. Although this method is slow because the berries take longer to ripen, they could be offset by long -term ecological benefits. These include: offering greater soil stability provision of wildlife cover, especially for birds, protects coffee plants from extreme weather conditions, lower evaporation rates and therefore greater water availability for coffee plants. Others are cool damp plants and use of less synthetic fertilizer, and revenues from carbon credits. It is reported that farmers among the 8 communities along Mexico's Sierra Madre de Chiapas are producing coffee with minimum environmental impacts for which there is a growing market demand. The farmers have been joined by other land owners in the sale of environmental services, receiving a payment for carbon sequestration through the restoration of deforested and degraded areas. At the moment, they sequester 1,678 tons of carbon at a rate of $10 per ton. This innovative combination of activities has been promoted through an initiative called "Building a Model of Conservation Coffee and Carbon Credit in the Sierra Madre de Chiapas", managed by Cooperativa AMBIO, a Mexican NGO dedicated to rural development through sound natural resources management. The project is supported by the Critical Ecosystem Partnership Fund.[1] If Rwanda adopted this approach, it would deliver on its above targets for environment under EDPRS while at the same time tapping additional economic benefits.

Source: Goetz Schroth

8. The search for profitability and growth on one hand and environmental sustainability on the other puts Rwanda at the centre of difficult debate. That debate exists between those who argue that environmental policies, standards and regulations will create additional costs to the WCS, thus impairing their competitiveness and those who argue that environmental sustainability is the pillar for enterprise profitability. This paper argues that it is more rewarding to adopt a "win-win" long term strategy for both business and environment in Rwanda.

9. The goal of this analytical case study is to open up policy dialogue aimed at improving the competitiveness of coffee industry particularly from the environmental point of view. Specifically the objectives were:
    (i) to describe the current contribution of coffee sector to the sustainable development agenda for Rwanda
    (ii) to show the position of wet coffee processing in the coffee value chain in Rwanda and the implications for mainstreaming environmental issues
    (iii) to assess the environmental aspects related to wet coffee processing and their likely costs and benefits
    (iv) to identify the necessary policy measures to propel Rwanda coffee into global competitiveness from environmental perspective.

10. Owing to the few days allocated to the study[1], this report is based on the review of existing documents, literature and selective interviews (See Annex 1).

B: Analytical framework for describing the environmental aspects of wet coffee processing

11. An analytical framework in Figure 1 has been used to explore the linkage between environmental policy and competitiveness and related costs and benefits in the wet coffee processing. It builds upon a similar best practice framework by OECD, 2010[2]. The framework uses a bottom-up approach, from a firm to the sector and the country at large. It has been argued that too little attention has been paid to firm-level analysis in environmental policy debate (DeCanio 2008) and that an understanding of firm-level foundation of competitiveness is crucial (Porter, et al 2007).

12. Studies on the relationship between environmental performance and economic performance worldwide have produced contradictory results. Some have found evidence of both a positive relationship (e.g Konar & Cohen, 2001; Wahba, 2008) and a negative relationship (e.g Wagner et al, 2007) between the environmental and economic performance of a firm. The main lesson for Rwanda is that the search for environmental compliance and economic competitiveness must be a continuous engagement, supported with appropriate policies.

13. At the firm level, CWS may cause either positive impacts or negative impacts. The firm will continue to pursue those actions that create positive impacts if it is directly rewarded e.g through premium price, bigger customer portfolio, entry into lucrative market or fiscal incentive. On the other hand, the activities of the firm may create negative impacts e.g water and air pollution. If there are national standards for compliance with water and air pollution quality, the firm may be compelled to invest in technologies that ensure good water and air quality. It would incur a cost to access that technology. From the firm's perspective, it would only be fair if all CWS comply with environmental standards to avoid distortions at sector level. Besides, it would be in the interest of CWS to invest in environmentally friendly technologies if it reduces their costs related to environmental compliance, and improves the customer image for their coffee. In turn, the economic performance at firm, sector and national level could provide evidence to be used to adjust the environmental policy at sectoral or national level.

14. Another key feature in the framework is that for firms or CWS to be competitive, they must get support from the sector (MINAGRI) and the government generally. Sometimes there is very thin line between the two levels. Suffice it to mention that the MINAGRI and the government are already offering the following to CWS:

    - removed export taxes for fully-washed coffee
    - provided equipment to washing stations, including coffee pulping machines, generators, and drying tables

[1] Only 6 days were allocated to this study
[2] OECD [2010]: Linkage between Environment policy and Competitiveness. OECD Environment Working Papers No.13

- conducted trainings on washing station management and processing high quality coffee to meet international demands

- assisted co-operatives and investors in finding international markets for their coffee

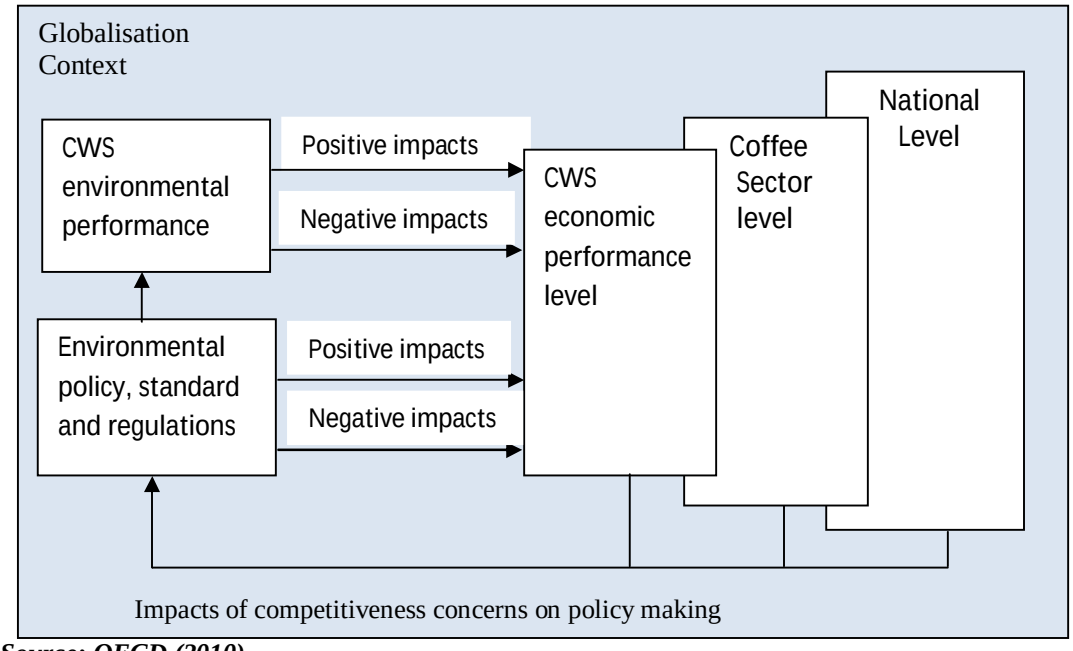
15. The analytical framework in Figure 1 also incorporates the globalisation context, whereby the trade policies, rules and preferences of coffee consumers can exert pressure on country level operations by firms and the sector. In that broad picture, the meaning of competitiveness at different analysis levels in this paper has been derived from Adams, 1997:

- Competitiveness at the firm level refers to an ability of a firm to sell goods and services in market and stay in business

- Competitiveness at the sectoral level refers to the aggregate competitiveness of the firms that operate within a given sector in an economy, compared to international rivals

- Competitiveness at the national level refers to an ability of a country to increase its economic standard of living.

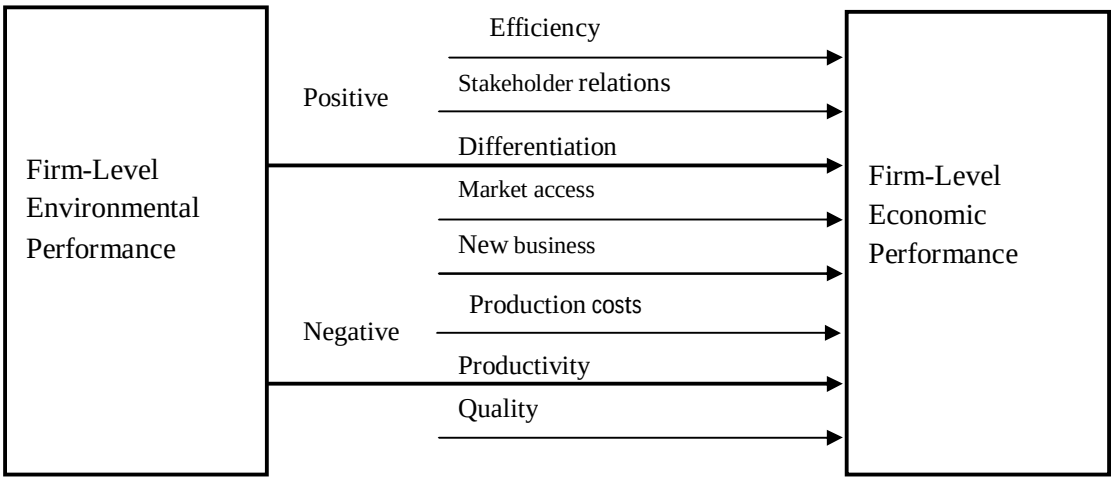
Figure 1: Analytical framework on the linkage between environmental policy and competitiveness



Source: OECD (2010)

16. Building on Figure 1, Figure 2 is given to illustrate the positive and negative linkages between firm-level environmental and economic performance (see e.g. Jaffe et al., 1995; Ambec & Lanoie, 2008; Lankoski, 2008a).

Figure 2: Mechanisms from firm-level environmental performance to firm-level economic performance



Source: OECD (2010)

17. Five different mechanisms can be distinguished through which positive competitiveness impacts may arise from environmental performance. First, improving environmental performance may result in improved resource efficiency, and ultimately cost savings e.g saving in energy and water use, both of which translate in financial gains.

18. Secondly, improving environmental performance may result in improved stakeholder relations, which can produce cost savings in transactions with various stakeholder groups. It can also build a good neighborliness. It was gathered that many CWS in Rwanda are improving the waste management practices to avoid odour from husks to adjacent households. Besides, such CWS can attract and retain staff because of a clean working environment. Article 6 of Organic Law No.04/2005 puts it clearly that "Every person in Rwanda has a fundamental right to live in a healthy and balanced environment."

19. Thirdly, improving environmental performance may allow product differentiation. High environmental performance may make the product or service more attractive in the market, and provide more value for the customer, which can increase revenue through a price premium or an increased sales volume. It has already been stated that the GoR, through the coffee strategy is pursuing such product differentiation by emphasising fully washed specialty coffee.

20. Fourthly, improving environmental performance may improve market access, and finally, it may contribute to the creation of new business.

21. On the other hand, three different mechanisms can be distinguished through which negative competitiveness impacts may arise from environmental performance. First, improving environmental performance may require increases in direct production costs. Capital investments may need to be incurred for machinery, equipment, and buildings. Moreover, operating costs for materials, energy, and labour (including management time) may

increase if the new inputs are more expensive or if they are needed in larger quantities. (Jaffe et al., 1995).

22. Secondly, in addition to these direct cost increases, improving environmental performance may reduce productivity in more subtle ways. The new processes and production practices may be less efficient, and the transitional period may involve switching costs, obsolete capital and production disruptions. The implication is that firms may need support to manage and survive that transition.

23. Thirdly, improving environmental performance may adversely affect the perceived quality, e.g. efficiency or appearance, of the firm's product or service, resulting in revenue loss. For example, customers may believe (falsely or not) that organically produced coffee is using too much labour, including child labour.

C: Importance of coffee to the Rwandan economy

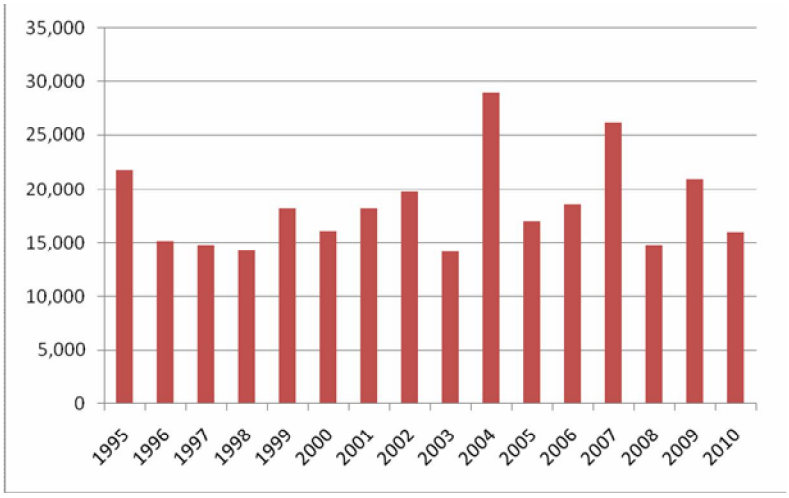
24. First and foremost, the earnings from coffee have relatively grown over the years (Table 2). Sometimes, its contribution has been more than 30% of exports. It is thus appreciated why the GoR prioritized it for export growth under its EDPRS. However, the contribution of coffee would have been much higher had the production steadily grown. Rather instead, it has been greatly fluctuating (Figure 3).

Table 2: Major BOP Components Developments (in millions of USD)

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Trade Balance	-157.8	-131.5	-136.8	-154.7	-177.87	-228.67	-299.02	-404.39	-624.16
1.Exports of which	69.0	93.6	67.4	63.1	98,05	124.98	147.38	176.77	256.56
-Coffee	22.52	19.36	14.65	15.01	32.23	38.27	54.04	35.67	46.91
-Tea	24.3	22.7	22.0	22.5	21.55	24.38	31.86	31.52	40.05
2. Imports (fob)	226.89	225.02	204.15	217.74	-275.93	-353.64	-446.40	-581.16	-880.72
% contribution of coffee to exports	32.64	20.68	21.74	23.79	32.87	30.62	36.67	20.18	18.28

Source: NBR, Department of Foreign Exchange and Balance of Payments

Figure 3: Trends on coffee production in Rwanda, 1995-2010



Source: Rwanda Coffee Development Authority

25. There are several factors explaining the overall decline of coffee production.

- *Political instability*: The war that started in 1990 caused a reduction in maintenance of coffee plantations. Furthermore, the political instability discouraged both private and public sectors from making long-term coffee investments. Good governance is thus a necessary condition for economic growth.

- *Lack of incentives:* As farm gate prices continued to decrease, farmers did not have sufficient purchasing power or the incentive to acquire inputs such as pesticides and fertilizers.

- *Old coffee tress:* The 1998 coffee census revealed that 14.2 % of all the coffee trees needed to be replaced (OCIR, 1998). From an agronomic view point, coffee trees with more than 7 years of production need to be replaced, otherwise the production starts declining.

- *Low-yielding varieties:* Using the regional yields as benchmarks (0.77 to 1.15 kg of dry parchment coffee per tree and per year), Rwanda's figures show a low level of productivity with only 0.33 kg of parchment coffee per tree and per year (Loveridge et al., 2002). Low yields can be explained in part because the trees currently planted are low-yield varieties, but also because they are poorly maintained.

- *Decline of coffee prices in international markets*: In 1989, there was a suspension of coffee quotas by the International Coffee Agreement, which resulted in low world coffee prices and low farm gate prices. As a result, there was lack of interest among coffee growers to take care of their plantations, resulting in low productivity.

26. The fall in coffee production, and subsequently in foreign exchange earnings, trade balance and ultimately balance of payments have also been traced to climate change related phenomenon. This is evidenced from the Annual Reports by National Bank of Rwanda, 2008.

"*Agricultural export products (coffee and tea) which represented more than 30% of Rwanda's exports in 2008 depend on climatic conditions that are beyond the country's control" page 44*.

27. Likewise, the Rwanda Coffee Strategy attributes the cyclical nature of coffee production to unfavourable weather conditions and the prevalence of disease [pg 32]. Arabica coffee is particularly sensitive to extreme weather conditions including drought.

28. The main lesson is that the GoR can no longer keep regarding climate change as a risk. Instead, it is challenged to identify and mitigate that risk so that coffee's contribution to development is sustained.

29. The second important contribution of coffee industry is employment generation. So, coffees sector is one of those leading as far as meeting Vision 2020 pillars with respect to employment generation. Besides, coffee growing has the potential to improve household income, and to reduce poverty generally. Recent estimates find that there are 500,000 coffee farmers in Rwanda[3]. It is projected that they will experience a higher income growth (almost 4% per year) than other farmers who do not cultivate cash crops[4]. These are generally smallholders who have on average 150 plants with a total area planted estimated at 27,000 ha, approximately 3% of the total arable land[5]. A 20% increase in coffee producer prices could reduce the poverty incidence among coffee farmers by almost 6% points which corresponds to about a half percent reduction in national poverty incidence, or about 16,400 people. A doubling of the price received by half of coffee farmers could reduce the incidence of national poverty by about 5%[6].

30. It is also reported that facilitating the shift out of subsistence into coffee production for farmers could reduce the national poverty headcount index by more than a quarter [MINAGRI, 2009] Higher incomes from coffee would also spill over to affect the labor market (increasing the number of farmers who hire labour) and the markets for food and other local non-farm goods in rural areas (since farmers will have more disposable income).

31. The price that cooperatives and non-cooperative (private sector) coffee washing stations are paying farmers for cherries has risen from 60 to 80 Rwandan francs in 2004 to between 160 and 180 Rwandan francs in 2008. Murekezi and Loveridge found that farmers who sell coffee cherries to washing stations increase their annual expenditures per adult equivalent by 17% as compared with farmers who sell lower quality parchment coffee. The authors

[3] Coffee Awakens a national economy, SPREAD, April 19, 2008
[4] Promoting Pro-poor agricultural growth in Rwanda; Challenges and Opportunities, World Bank Report 2007
[5] PDCRE, 2008
[6] Brenton, P (2006) Trade, Coffee and Poverty in Rwanda; World Bank

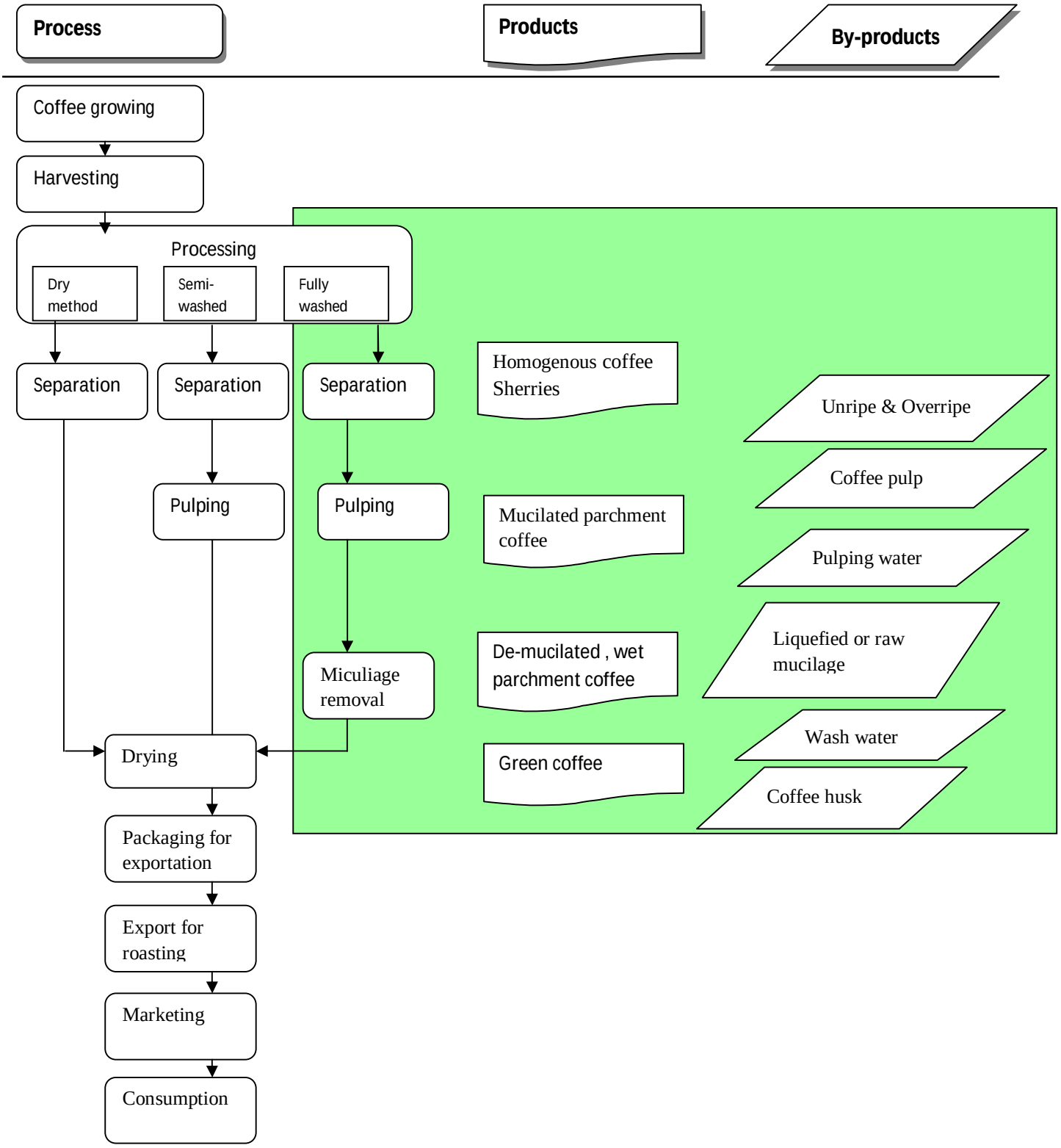
found that post trade liberalization reform, coffee farmers have increased their food consumption and their overall household expenditures. This leads to improved food security and to generally improving economic conditions for coffee farmers. It is therefore not a surprise why the GoR looks to CWS as being central to its realization of the Coffee Strategy.

32. A fourth benefit to coffee industry is its backward and forward linkages to the economy, thereby supporting the growth of other enterprises and employment. Such industries include banking and insurance, transporters, warehousing companies, producers of packaging materials to mention but a few.

D: The Value Chain of Coffee in Rwanda and the position of wet coffee stations

33. Figure 4 provides the value chain of coffee in Rwanda, the position of wet coffee processing, the products and by-products. The shaded area is the main boundary for the study.

Figure 4: Position of wet coffee processing, its products and by-products in the Value chain



34. As depicted in the above figure, primary coffee processing is a very essential activity in the coffee value chain. It is the method by which the ripe coffee fruits (cherries) go through a number of operations aimed at extracting the beans from their covering of pulp, mucilage, parchment and film to improve their appearance. The resulting clean coffee can then be roasted and ground to obtain the coffee powder which if fit for human consumption. For long time there has been two main techniques used to obtain the clean coffee; namely wet and drying processing in Rwanda. In Brazil and Indonesia, there is also a hybrid of the two processes called semi- dry processes. A more recent type called ecological processing is not widely adopted.

35. Presently, there are 187 CWS participating in wet coffee processing. The number has risen from a mere 2 in 2002 due to the liberalization of the processing. As shown in Table 3, the CWS have varying installed capacities, implying that their economies of scale for processing and marketing also differ. For example, it is reported by OCIR-Cafe staff that some of the CWS with installed capacities of between 150 to 300 tonnes are using expensive bigger hullers than should otherwise be the case. By implication, they are tying a lot of their capital into the investments and increasing pay-back-periods.

Table 3: Distribution of CWS in Rwanda by installed capacities (tons) of cherries

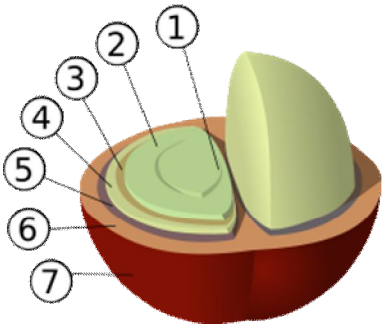
Tonnes	**No. of CWS**
150	30
250	49
300	1
500	81
1000	23
1500	2
2000	2
Total	**187**

Source: OCIR CAFÉ

36. Although there has been a significant increase in the number of washing stations, Rwanda only produced 25% of its fully washed target in 2007. At the end of 2007, there was 112 CWS with the capacity to process 60,000 tons of cherries and produce 11,500 tons of parchment coffee but these washing stations only processed 17500 tons of cherries and produced 3650 tons of parchment coffee (a little over 3000 tons of green coffee), which means that they were operating at 30% of their capacity on average due in part to low volume of inputs and in part to improper operations. If Rwanda wants to meet its specialty coffee targets, the operations of CWS need to significantly improve.

37. In wet coffee processing, the desire is to end up with the inner bean, the rest of the other components having been removed (see Figure 5). Briefly, in the wet process, the fruit covering the seeds/beans is removed before they are dried. Coffee processed by the wet method is called wet processed or washed coffee. The wet method requires the use of specific equipment and substantial quantities of water.

Figure 5: Structure of coffee berry and beans



1: center cut 2:bean (endosperm) 3: silver skin (testa, epidermis), 4: parchment (hull, endocarp) 5: pectin layer 6: pulp (mesocarp) 7: outer skin (pericarp, exocarp)

38. The coffee cherries are sorted by immersion in water. Bad or unripe fruit will float and the good ripe fruit will sink. The skin of the cherry and some of the pulp is removed by pressing the fruit by machine in water through a screen. The bean will still have a significant amount of the pulp clinging to it that needs to be removed. This is done either by the classic ferment-and-wash method or a newer procedure variously called machine-assisted wet processing, aquapulping or mechanical demucilaging.

39. In the ferment and wash method of wet processing the remainder of the pulp is removed by breaking down the cellulose by fermenting the beans with microbes and then washing them with large amounts of water. Fermentation can be done with extra water.

40. The fermentation process has to be carefully monitored to ensure that the coffee doesn't acquire undesirable, sour flavours. For most coffees, mucilage removal through fermentation takes between 24 and 36 hours, depending on the temperature, thickness of the mucilage layer and concentration of the enzymes. The end of the fermentation is assessed by feel, as the parchment surrounding the beans loses its slimy texture and acquires a rougher "pebbly" feel. When the fermentation is complete, the coffee is thoroughly washed with clean water in tanks or in special washing machines.

41. In machine-assisted wet processing, fermentation is not used to separate the bean from the remainder of the pulp; rather, this is done through mechanical scrubbing. This process can cut down on water use and pollution since ferment and wash water stinks. This is environmentally and socially not appealing. In addition, removing mucilage by machine is easier and more predictable than removing it by fermenting and washing. Any wet processing of coffee produces coffee wastewater which can be a pollutant. Around 130 liters of fresh water is required to process one kilogram of quality coffee.

42. After the pulp has been removed what is left is the bean surrounded by two additional layers, the silver skin and the parchment. The beans must be dried to a water content of about 10% before they are stable. Coffee beans can be dried in the sun or by machine but in most cases it is dried in the sun to 12-13% moisture and brought down to 10% by machine.

43. When dried in the sun coffee is most often spread out in rows on large patios where it needs to be raked every six hours to promote even drying and prevent the growth of mildew. Some coffee is dried on large raised tables where the coffee is turned by hand. Drying coffee this way has the advantage of allowing air to circulate better around the beans promoting more even drying but increases cost and labor significantly. After the drying process, the parchment skin or is thoroughly dry and crumbly, and easily removed in the Hulling process.

44. As economies globally start to rigorously pursue "green economy" or "low carbon" growth paths, emphasis will be put to Life Cycle Assessments (LCA). LCA is a methodology used for analyzing and assessing the environmental loads and potential environmental impacts of a material, product or service throughout its entire life cycle, form raw materials extraction and processing, through manufacturing, transport, use and final disposal[7]. It allows the perpetrators of negative environmental externalities to internalise them at source.

45. In a case study of LCA applied to coffee production, it was found that the cultivation stage contributes the most to terrestrial eco-toxicity and eutrophication (contributions greater than 97%); the consumption stage contributes the most to air acidification, aquatic eco-toxicity, human toxicity, greenhouse effect, depletion of ozone layer and photochemical oxidant formation. The disposal stage contributes to aquatic eco-toxicity (after consumption) and to eutrophication (after cultivation). The contributions made by transport are very limited but influence photochemical oxidant formation, greenhouse effect, human toxicity and air acidification (after consumption and cultivation) and the depletion of ozone layer and aquatic eco-toxicity (after consumption but before cultivation). The contributions of the processing and packaging stages are much lower than in the above stages [Roberta Salomone, 2003].

46. The main lesson for Rwanda is that to make coffee product environmentally competitive, it must formulate policies that would trigger the necessary actions to deal with negative impacts along the relevant coffee value chain stages. Secondly, Rwanda would need to come up with simple and understandable guidelines and codes of practice for different actors in the coffee value chain. It was however gratifying to find that recently, it has released the Coffee Regulations, which include guidelines and methods of coffee processing at CWS (See Annex 2).

47. In addition, the GoR needs to go a step further and help CWS audit themselves with regard to operational efficiency, inventory analysis and impact assessment so that at their own level, they become more profitable than is the case. Finally, Rwanda needs to invest in market research to know the consumer preferences in the countries to which it exports

[7] Roberta Salomone [2003]

coffee. In the long run, Rwanda should invest in the exporting its coffee as final product ready for consumption, that is after value addition.

E: Costs and benefits of addressing environmental concerns in wet coffee processing

48. It has been shown in Figure 4 that CWS produce a lot of by-products. They also use a lot of inputs like water, energy and labour. This section analyses CWS from a long term sustainability angle "with a win-win" strategy for growth and environmental management.

49. Before considering additional costs and/or benefits from internalizing environmental impacts of wet coffee processing, it is important to describe the analytical framework that CWS would use to maximize their profitability. It is given as follows:

$NPV = B_d - C_d$ where,

NPV = Net present value
B_d = Direct benefits
C_d = Direct Costs

50. Any CWS would be profitable if its NPV would be above 0, that is, where the discounted benefits would exceed the profits[8]. That is one of the objectives of the coffee strategy.

51. However, in search of sustainable development, firms as well as governments are expected to internalize externalities. The internationalization of the externalities in the CWS would alter the above analytical formula to:

$NVP = B_d + B_e - Cd - C_e$

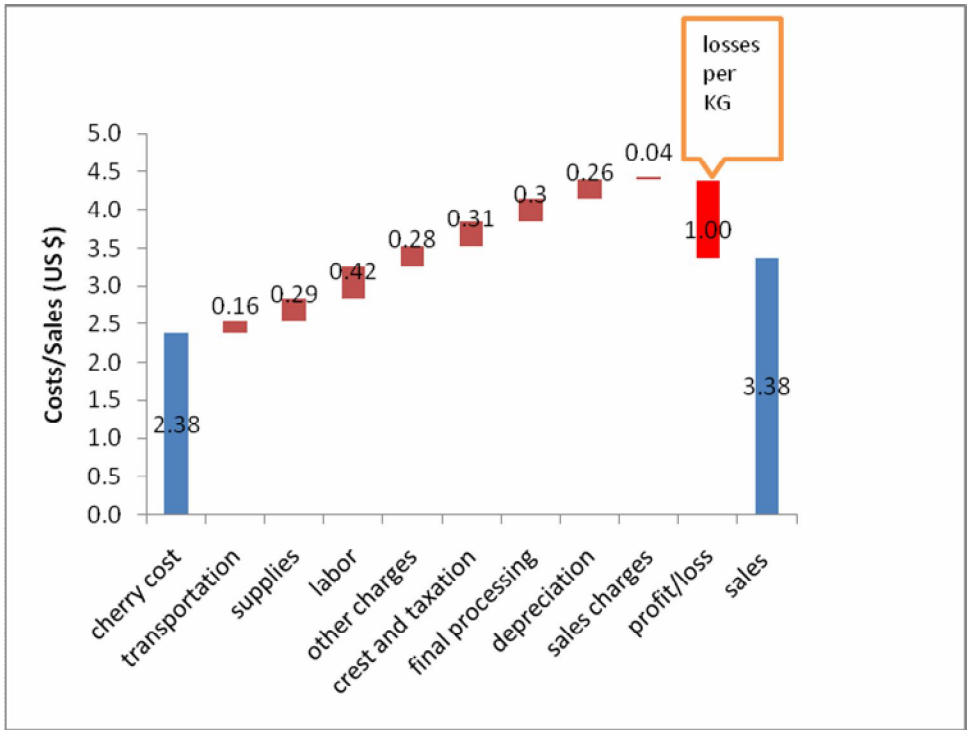
Where:
NVP = Net Present Value
B_d = Direct benefits
B_e = External or environmental benefits
C_d = Direct Costs, and
C_e = External or environmental costs (Pearce & Turner, 1990)

52. The above formula responds to Agenda 21 which advocates for ensuring the integration of economic, social and environmental consideration in decision making at all levels in government and private sector [UN, 1992]. In this paper, a two phase approach has been taken, namely to first analyse the profitability of CWS "before" internalizing the externalities or environmental impacts and secondly to describe the additional benefits and costs if they would internalize them.

[8] Other decision criteria that CWS can use are Benefit Cost ration and internal rate of return. Under the formula, a CWS would be profitable if the Benefit Cost Ratio is greater than one. Under the latter, it would be profitable if the Internal Rate of Return is greater than the social discount rate

53. Based on averages for 26 CWS in 2007, OCIR CAFÉ found that CWS were generally making losses. The international price could not help them cover their costs (Figure 6). On the other hand, ordinary coffee fetched a profit of US $ 0.29 per kg. This tempted some CWS to switch to ordinary coffee. The concern to the government is that such switching could jeopardize the relationships with buyers of fully washed coffee. Nonetheless, the main lesson is that the search for profitability in the short run can divert CWS which may be pursuing a sustainable path for processing high quality fully washed coffee.

Figure 6: Coffee washing station costs for 1kg of Green Coffee (Average from 28 stations in 2007)



Source: MINAGRI [2009]

54. If the CWS can start to contain their operational costs, they stand to benefit from the recent world coffee prices. In March 2011, the monthly average of the ICO composite indicator price rose by 3.8%, from 216.03 in February to 224.33 US cents/lb, the highest level in 34 years since 1997 [Figure 7]. The price increase was marked in the case of Robusta, reducing the differential with prices of other Milds by 2.6%. Reasons given for the price rise is that world stocks are falling at a time when world consumption is recovering after the global economic crisis. Further coffee consumption is growing more rapidly in the exporting countries particularly Brazil, Ethiopia and Vietnam [ICO-March 2011].

Figure 7: ICO composite indicator price

Source: ICO-March 2011

55. There are several reasons why many CWS are making losses or are not as profitable as they should. It has already been described how some of them are over-capitalized, a factor that prolongs their pay-back-periods.

56. Whereas washing stations fully wash all coffee cherries that they receive, a large proportion of the coffee that is produced does not qualify as fine or specialty coffee and so, despite going through the expense of fully washing, no premium is received. This problem serves to reduce the profitability of fully washing coffee. According to the Coffee Strategy (2009-2012), the average cost of processing fully washed coffee is $1.25 per kg while costs for semi-washed coffees are around $0.5 per kg. Hence, if the price differential between fully washed and commercial coffee is less than $ 0.75 per kilo, it is more profitable to produce commercial coffee. The main lesson is that the survival of CWS will greatly depend on production of high quality cherries by farmers.

57. By other countries' comparison, Rwanda's CWS are inefficient in water use. It is estimated that a CWS that has the capacity to process 625 tons of cherries during a coffee season (to produce 125 tons of parchment coffee), operating at 4% capacity, would need 400m3 of water per day if there was no water recirculation and 113m3 if there was full recirculation. Certain CWS don't have adequate water resources in terms of quality and quantity at an acceptable distance. Many have difficulties in waste water treatment, etc. A lot of these issues arose because of either the stations have been improperly situated or because the design and construction of water supplies and distribution systems within the stations are inefficient.

58. The inefficient use of water is depicted in the Draft Coffee Regulations for Rwanda. Its standards for water use show that Rwanda CWS would use 5 to 15 times more water to turn out a ton of cherry [Table 4]. Many CWS located themselves where they could easily get the water, and in that case, their main cost was the investment cost to tap water. They do not pay for water. If that was to command a price e.g water extraction fees, it would further increase the operational costs of CWS. On international level, it would reduce the competitiveness of Rwanda's coffee.

Table 4: Amounts of water used for wet coffee processing (per ton cherry)

Columbia	1-6 m^3
Kenya	4-6 m^3
Papua New Guinea	4-8 m^3
Vietnam	4-15 m^3
Rwanda	75m^3*; 25 m^3**

* If there is no water re-use, **If there is water re-use

Source: Draft Regulations

59. Thirdly, many CWS are incurring high costs of energy use because they depend on generators since they are remote from electricity supply. Additional increases in operational costs emanate from high transportation costs, poor management of CWS, poor financial planning and management and weak human capacities. Many CWS have poor relations with banks because of the above factors, and in turn, the banks cannot assist them in time.

60. It will only be practical and feasible for CWS to address any environmental issues as they address the broader operational weakness, and not vice versa. Further, owing to their varying scales (both in terms of installed and actual operational capacities), CWS impact on environment differently. But, because they make up a key constituency in the value chain, they must collectively be mobilized, sensitized and systematically supported to mainstream environmental issues in their operations. Short of that, the competitiveness of Rwandan coffee from environmental aspects may remain low.

61. It has been shown in Figure 4 that wet coffee processing produces several by-products most of which could be put to economic use. 1000kg of fresh berry gives about 400kg of wet waste pulp and only 160kg of exportable green bean.[9] Coffee pulp is mainly composed of water and sugar. The five common sustainable coffee by-products include the following**:**

[9] Jan von Enden

- Composting

62. Coffee pulp is a rich source of nutrients: 0.5% nitrogen; 0.15% phosphorus, and 0.5% potassium. It can be treated and used as organic fertilizer. Usually the coffee pulp is placed on piles and left to compost for about 3 to 12 months. During that time, it turns into coffee pulp turns into rich, black humus excellent for composting. Using organic fertilizers improves soil conditions and increases agricultural yield. Farmers save money otherwise spent buying inorganic fertilizers. In turn, they can start to earn premium price associated with organic coffee.

63. It was gratifying to find that OCIR-CAFÉ is training CWS in making manure from pulp. One CWS was reported to have produced more than 300 bags. Turning 'waste' into 'goods' and generating 'green jobs' will be another source of incentive at firm level. Investment to scale up such initiatives should be scaled up.

- Mushroom planting soil

64. Coffee pulp can also be used as planting soil for mushroom production. When used for this purpose, the coffee pulp is fermented for about two days. The pulp is then pasteurized with hot water, drained, dried and mixed with mushroom spores. Next, the mixture is put in plastic bags with holes where the mushrooms develop for about 3 to 4 weeks. When the mushrooms grow out of the holes, they are collected. One bag allows for about 2 to 3 mushroom harvests. The fresh mushrooms are for table consumption or they can be dried for sale. The income from mushroom growing can be significant for the farmers who do this.

- Animal feed supplement

65. Coffee pulp is very rich in nutrients. It can be dried and used in animal feed. The pulp needs to be treated as quickly as possible to prevent the development of fungi. Usually, coffee pulp is treated with calcium hydroxide and dried under pressure. Another way to dry pulp, in the absence of industrial equipment, is to mix the coffee pulp with sugar cane molasses or other inorganic substances before storing the mix in silos. The resulting silage is available for use after 3 weeks and can remain stored for up to 18 months. The use of coffee pulp for this by-product appears to offer limited value because the cost of processing the pulp can exceed the gain derived from its use. The research on the effects of caffeine, potassium and other natural chemicals in the pulp on the health of animals is ongoing and will be influential for the future of this by-product.

- Energy source for heat exchangers of coffee driers

66. The most energy consuming step in coffee processing is drying. Sun drying is very common and offers many benefits but has drawbacks as well. It conserves energy, minimizes the use of fossil fuels and reduces costs.

67. However, parchment coffee can be contaminated with dust and dirt during the sun drying process. Rainstorms happen without warning and are a challenge for farmers to prevent bean re-wetting which can promote bacterial infections and moldy growth.

68. Because sun drying is time intensive, many coffee processors choose mechanical drying. The downside is that the cost to operate mechanical dryers is high and can cut down on margins. Using coffee parchment husks as the energy source for burners for heat exchangers of coffee driers is both a great environmentally friendly waste-recycling and energy-saving solution.

- Biogas and fertilizer

69. AD-Coffee Waste System (AD-CWS) as a technology can use waste generated by coffee processing to generate biogas and fertilizer. Biogas can be used at source to dry coffee beans, thereby saving on energy costs and fertilizer can be sold to generate additional income. The other saving is of course associated with reduced pollution into water ways and commitment costs of water cleaning, loss of riverine biodiversity, etc[10].

70. It would be a process for CWS to fully internalize the environmental impacts. This is because it also entails additional costs. So CWS would be weary whether there would be enough benefits or incentives to enable them affect these costs.

71. Additional costs would include costs of environmentally friendly technologies, training of staff and auditing their operational systems. An example has been given in Annex 3 to demonstrate potential gains from Clean Development Mechanisms. CWS in Rwanda should be supported for Clean Development Mechanisms. The reason for adopting CDM is that the coffee market is now sensitive to environmental issues.

72. Rwanda's 99% of its coffee is sold globally. As such, it has to take cognizance of the factors affecting demand in the foreign market. One of such factors is consumer preference for "sustainability coffee". It is now being procured by those who can label or certify it as such for consumers. Top on the list of those buyers are Fair Trade, Certified Organic Certification, Rainforest Alliance Certified, UTZ Certified, the Common Code for the Coffee Community (4C) and SMBC "Bird friendly". There are other corporate programmes like Nespresso ecolaboration and Starbucks C.A.F.E Practices. Many of these are also starting to introduce incentives to adapt to and mitigate against climate change impacts. Rwanda is already curving out a niche with Starbucks.

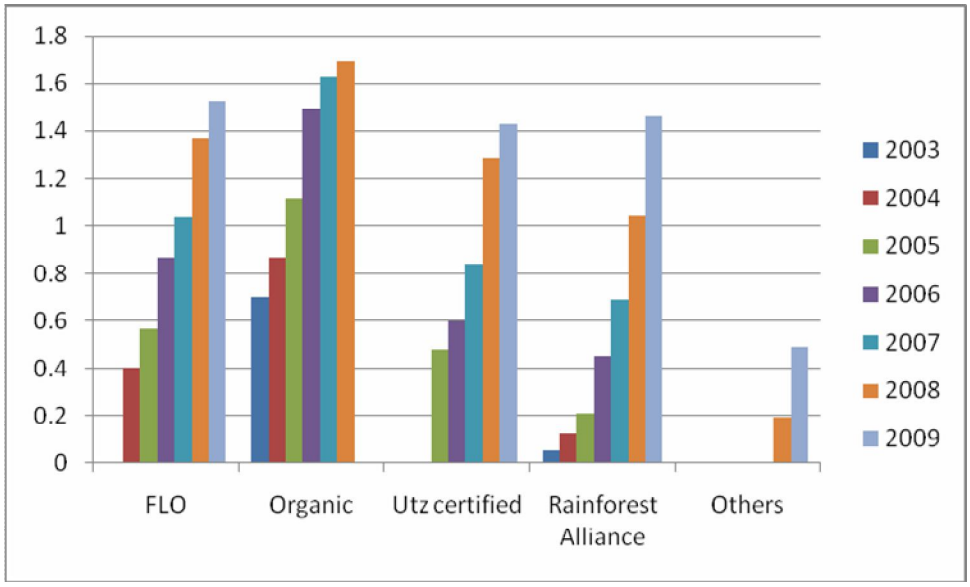
73. Coffees produced as part of these schemes are collectively referred to as "sustainable coffee" to differentiate it from coffees from conventional production systems. The main idea behind these schemes is to create market based incentives for those coffee farmers who produce their coffee in a socially and environmentally responsible way. Social and environmental responsibility is defined in terms of the adoption of practices that protect the environment and social fairness in coffee production.

[10] Ysabel E. Bombardiere (2006) The potential of Anaerobic Digestion Technology to treat coffee waste in Huatustco, Mexico

74. According to Calo and Wise (2005), sustainable coffee schemes represent a market-based incentives to communicate information about coffee production to consumers thereby correcting market failures to value their associated attributes (health, environmental protection, and social justice). The communication of product information in the market place has the potential to alter demand, thereby providing new and promising opportunities for coffee farmers. Price premiums and rising demand create incentives for farmers with the capacity to respond by changing their production structures and take advantage of the new market opportunity.

75. The sustainability coffee segment has been increasing by about 20-25% each year, compared to about 2% for conventional coffee. It is projected that certified coffee might grow from 8% of 2000 to 20-25% of global green coffee trade by 2015. In wealthier markets e.g. USA and Western Europe, that market share has already reached 10-40%. To sum up therefore, and as evidenced by Figure 8. Rwanda has to register a strategy that the future competitiveness of coffee will be driven by environmental sustainability. As mentioned earlier, CWS have shown willingness for cleaner production. But, that is a long term process that needs to be supported systematically.

Figure 8: Trends in sales of certified or verified coffee (million 60-kg bags)



Source: International Trade Centre (2010)

F: Conclusion and recommendations

76. Rwanda has committed itself to penetrate the market for "specialty" and/or "sustainability" coffee. In that respect, it must be seen to satisfy the needs of globally growing green consumerism. Besides, it is in the interest of Rwanda to take advantage of that fast growing market segment.

77. However, the CWS which have been the focus of this study, are but a few of the many actors in the coffee's value chain. The GoR has targeted them with special investment programme. It has equally targeted other actors. The challenge it faces is that of ensuring that all the actors are able to financially profitable, as an incentive to take on additional innovations, and investments. Such include those for environment.

78. Presently, many CWS are not operating efficiently. They could reduce on their losses if they employed qualified staff, adopted modern management techniques and maintained good relations with credit institutions. Unless they therefore improve on their profitability, they will consider demands to take on additional investments e.g for environment as a burden. The current high prices for coffee offer an incentive and entry-point to effect many reforms. That price will be relevant if it is fairly and equitably shared in the chain including benefiting the poor coffee farmers.

79. The many by-products from wet coffee processing offer additional sources of revenue, employment and new enterprises. It is therefore high time CWS started putting a price on those by-products. The current initiative by OCIR-Café to support CWS to make organic manure from pulp should be upscaled therefore. Equally, OCIR-Café needs to the CWS through cleaner production processes as it would improve their efficiency in the use of resources like coffee cherries, water, electricity and labour.

References

1. Abdoul Murekezi [2009]: Essays on the Effects of Coffee market Reforms, Supply chains and Income improvements in Rwanda.
2. Adams, J. [1997]: Environmental policy and competitiveness in a globalised economy: Conceptual issues and a review of the empirical evidence. In: *Globalisation and environment: Preliminary perspectives*. Paris: OECD.
3. Ambec & Lanoie, [2008]: Does it pay to be green? A Systematic overview
4. Brenton, P [2006]: Trade, Coffee and Poverty in Rwanda; World Bank
5. DeCanio [2008]: Book Review; Environmental Policy and Corporate behaviour: Ecological Economics (67(2)
6. Department of Environment and Climate Change NSW [2007]; Better Coffee, Less water
7. Goetz Schroth: Mitigation and Adaptation of Strategies for Global Change; Manuscript draft
8. ICO, [March 2011]: Monthly Coffee Market Report
9. International Trade Centre [2010]: Trends in the Trade of Certified Coffees.
10. Jaffe et al, [1995]: Environmental regulation and the competitiveness of U.S. manufacturing: What does the evidence tell us? Journal of Economic Literature.
11. Konar & Cohen, [2001]: Does the market value environmental performance? Review of Economics and Statistics; 83, 281-289
12. Lankoski, L. [2008a]: Responsibility and the "bottom line": A literature review of the effects of corporate responsibility on firm-level economic performance. Publications of the Ministry of Employment and the Economy
13. Loveridge et al., [2002]: "Decaffeinated?" Situation, trends and prospects for Coffee Production in Rwanda; Analysis of a rural household survey
14. MINAGRI [2009]: Rwanda National Coffee Strategy, 2009-2012
15. MINAGRI [2011]: Rwanda Coffee Regulations 2011
16. National Bank of Rwanda, [2008]: Annual Report
17. OCIR, [1998]:
18. OECD [2010]: Linkage between Environment policy and Competitiveness. OECD Environment Working Papers No.13
19. Porter, et al [2007]: The microeconomic foundations of prosperity; Findings from the Business Competitiveness Index. In Global Competitiveness Report 2007-2008.
20. Roberta Salomone [2003]: Life cycle assessment applied to coffee production: investigating environmental impacts to aid decision making for improvements at company level.
21. UN, [1992]: Agenda 21
22. Wagner et al [2002]: The relationship between the environmental and economic performance of firms; An empirical analysis of the European paper industry.
23. Wahba, H. [2008]: Does the market value corporate environmental responsibility? An empirical examination. *Corporate Social Responsibility and Environmental Management*.
24. World Bank and IFC [2011]: Doing Business Report
25. World Bank Report [2007]: Promoting Pro-poor agricultural growth in Rwanda; Challenges and Opportunities
26. Ysabel E. Bombardiere (2006) The potential of Anaerobic Digestion Technology to treat coffee waste in Huatustco, Mexico
27. ***http://www.usaid.gov/rw/our_work/programs/docs/factsheets/coffee.pdf***

Annex 1: List of people interviewed

Name	Title	Organisation	Contact
1. Elie Mutabazi	Programe Lending Manager	Bank Populaire	0788302881
2. Rose		KOBIL & Kisementi	
3. Monique Serumba	Programme Manager	UN-Habitat	0788458028
4. Tona Isibo	Planning Officer	ISAR	0788402540
5. Claver Ngaboyisonga	Head of Research	ISAR	0788309522
6. Rapael Rurangwa	Director General	MINAGRI	0788301498
7. Regis Muvowanashaka		NAFA	0782382240
8. Theodore	Nursery operator, Gicumbi		0788416805
9. Patrick Munyurwa		PAREF	0788635389
10. Robert Ndabavunnye	Rural infrastructure Engineer	MINAGRI	
11. Mutimura Gerald	Head of Agriculture	Bank Populaire	0788488184
12. Innocent Musabyamana	Programme Manager	LWH	078851355
13. Olivier Gatera	Retail Manager	KOBIL	0788302440
14. Asiimwe Robert	Deputy General Manager	UMWALIMU SACCO	0788301053
15. Baho Florence	Energy Officer	MININFRA	0788482710
16. Hakizimana Protai	Head of Production	OCIR-CAFE	
17. J.N	Production Engineer	Electrogaz	
18.			

Annex 2: Summary of guidelines and methods of wet coffee processing

1] Guidelines for the optimal operation of CWS

A: Water required at the washing station:

Water required for processing 1 ton of dried coffee is $75m^3$ if there is no water reuse by using water pumps to pump it back and $25m^3$ if there is full water reuse.

B: Vats for fermentation of coffee

Every washing station must reserve enough vats fort fermentation of coffee. The walls of vats must be painted with specialized paint that is not removed by muciliage.

C: Coffee washing channels

The channel used for washing coffee must have at least 30 metres of length, 0.60 metres of depth, 0.6 metres of width and the inclination of the base of the channel is 1%. The inner walls must be painted with specialized paint that is not removed by mucilage. For the grading of coffee, a separation tool is used to separate coffee based on its weight in every ten metres of the channel. The speed of water in the coffee washing channel must be equal to 350 litres per minute.

D: The number of coffee drying tables

$36m^2$ of drying tables are required in every two tons of the received coffee cherries. Coffee drying tables must be covered so as not to hinder the sorting out of deficient coffee during the rainy and severe sunshine period. The number of tables used for drying coffee after deficient coffee has been sorted out is determined according to the quantity of production the washing station can afford to handle. In general, the size of drying tables in general is 20 metres long and 1.50 metres wide and 1 metre high. That table is used to dry coffee from 3 tons of cherries. Those measurements might change according to the tools on the market.

2] Methods of coffee processing at CWS

Basing on the requirements for the international coffee market, it is recommended that the method of processing coffee requires the following chain of actions:

- Cherries that have been picked up should not exceed 8 hours before they are pulped
- Only ripe cherries picked that day are received and when deficient coffee has been sorted out
- In cases where the washing station does not have a machine capable of separating coffee depending on its weight, vats with water are used to separate them before being pulped
- In pulping coffee, specialized machines are used which do not damage coffee
- Fermentation of coffee is meant to remove mucilage from unpulped coffee

Method One:

Fermentation of coffee for a period between 12-18 hours not in water

Method Two:

Fermentation of coffee for a period between 12-18 hours not in water followed by fermenting it covered in water for a period of 30 hours. In both methods, coffee is covered during the period of fermentation of coffee not water so that the process is not affected by sunlight or rain.

Method three:

Using a machine that removes mucilage

- Grading of coffee by using water through the grading channel
- Putting coffee in water for a period between 16-20 hours after washing it
- Drying the coffee: It is done in the shed. Workers must avoid coffee being broken apart due to high temperatures or becomes moist rained on. Dried coffee heap must not exceed 40 millimeters of height. Drying of coffee has to be done quickly so that it is complete in a period of 4 hours.
- Drying coffee: Coffee heap must not exceed 40mm of height. The person responsible for drying coffee has to keep turing it around every 30 minutes. He has to avoid anything that can moist it. Well dried coffee has moisture of 12.5%. In evaluating the moisture of coffee using specialized measuring equipments (Humidimeter). In drying coffee, the washing station has to avoid mixing coffee that was bought in different days.

Removal of coffee from drying table and storing of well dried coffee: Removing of coffee from the drying tables according to the lot and avoid mixing coffee in different grades. Avoid lying coffee sucks on the ground (lying them on elevated tables). Not extending sucks close to the walls of the coffee store.

Source: MINAGRI [2011]

Annex 3: Cost-savings through cleaner production

Mountain Top Coffee (MTC) is a family-owned company that grows and processes coffee in New South Wales. In 2001, it embarked on a four-stage cleaner production project which run for 18 months. The aim of the project was to reduce total inputs, particularly water and energy and to reduce and reuse the waste products. The main motivation was to boost the firm's long term sustainability and competitiveness.

Stage 1 was the Environmental audit. Data on energy, wastewater, material resources and water usage was collected and compared against international benchmarks.

Stage 2: This involved using the results from the audit to develop and implement a cleaner production plan. MTC identified cleaner production opportunities in wastewater recycling and reuse, solid waste composting and energy reuse.

Stage 3 involved further investigation to analyze improvements in water quality and usage as a result of the work undertaken in Stage 2. Changes in energy, wastewater, material resources and water usage were monitored and measured as part of a post-harvest evaluation, and the cleaner production plan was revised.

Step 4 involved documenting the cleaner production outcomes as a case study. This was presented to other coffee growers and processors and disseminated through industry bodies.

MTC set up a composting system for coffee skins and dry husks. The compost is used to supplement organic fertilizer used on the coffee trees. MTC introduced many improvements to its wastewater system, including:

- Adding two new 2,500l concrete tanks for storing recycled water

- Installing timer-activated control valves to reduce water usage

Five environmental gains were registered;

- Water usage reduced from 10l to 1.5l for each kg of coffee processed
- Total water savings: 9ml/year
- Potential water savings throughout the NSW coffee industry: 90ml/year
- Improved quality of treated water: biological oxygen demand and total soluble solids reduced by 35-49%
- Coffee skins and dry husks are collected and composted, then put back onto trees as organic fertilizer

Financially, there were also savings. At the project start, coffee production was 40,000kg green coffee equivalent a year, using 1.5ml of water, and at project completion production was 100,000 kg green coffee equivalent a year, using 0.5ml of water. Reducing the quantity of wastewater means less water storage is required, there is lower demand for effluent storage and treatment and pumping costs are reduced. The estimated capital saving resulting from lower water usage is approximately $50,000. Secondly, the saving in water could be used for irrigation with potential income of $24,500 a year

Thirdly, solid waste composting has reduced the requirement for composted chicken manure by 40%, saving approximately $2,500 a year. Finally, planned energy reuse systems had a cost-saving og 35-40%, equating to more than $5,000 a year. The main lesson is that at sectoral level, the GoR working through OCIR should support CWS to adopt cleaner production

Source: Department of Environment and Climate Change NSW [2007]